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Effect of Herbicide Application on Weed Management in Green Gram [*Vigna radiata* (L.) Wilczek]

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Abstract

A field experiment was carried out at Bidhan Chandra Krishi Viswavidylaya (Nadia, West Bengal) during 2012 and 2013 (during March-May) in upland situation to judge the efficacy of the herbicides against weed flora in green gram crop field and also to find out the effect of herbicides on growth, yield and benefit cost ratio of green gram [*Vigna radiata* (L.) Wilczek] crop. The soil of experimental site was sandy loam in texture having neutral in soil reaction. The experiment was conducted with 14 treatments and laid out in Randomized Block Design with 3 replications. The green gram variety used was IPM-2-3.

It was observed that hand weeding resulted in significantly lower weed density and dry weight and gave better seed yield of green gram. Most of the herbicides were found effective in controlling weeds and maximizing seed yield of green gram. These treatments were at par with hand weeding twice at 20 and 40 DAS. Total weed free treatment showed the best performance in respect of yield and yield attributes of green gram crop and weeds management. The herbicidal treatments Fenoxaprop-p-ethyl@50 g *a.i.* ha^{-1} and @ 100 g a.i. ha^{-1} were found less effective for controlling weeds. Maximum benefit: cost ratio was obtained from Vellore 32(Pendimethalin 30 EC+Imazethapyr 2 EC)@1.00 kg *a.i.* ha^{-1}. Hand weeding treatments, though significantly reduced weed biomass and improved the grain yield, gave less benefit: cost ratio owing to higher cost of farm labour.

Keywords: Herbicides; Hand weeding; Green gram; Weed; Yield

Introduction

The pulses constitute an important group of crops and have been the main stay in Indian Agriculture, as they improve physical condition of soil and provide nutritious food and fodder. India has a distinction of being world's largest producers of pulses. However, India needs to make immediate strides in pulse production programme taking into account the extreme relevance of pulses in our diet. Increasing yield of pulse crops should be the top priority to fill up the existing gap in the requirement and availability of pulses. This will not only ensure food security but will also provide nutritional security, particularly to the large vegetarian population of our country. Among the grain legumes, green gram ranks third after chickpea and pigeon pea among the pulses in respect of production, and it can be grown throughout the year. In India, there is substantial scope of summer green gram after harvesting of winter crops due to its short duration in nature and deep rooted, it can be grown with limited irrigation. However weed infestation is one of the major constraints in green gram cultivation. The loss of yield due to weeds is quite high, ranges from 40-68%. In view of severe infestation of annual and perennial weeds in summer green gram, the potential yield is generally not realized. The available pre and post-emergence herbicide, pendimethalin, oxyfluorfen, fenaxaprop-p-ethyl and quizalofop-ethyl are able to check the emergence and growth of annual grasses and broadleaved weeds. Keeping the above in view and the known possible reasons, the present study was taken up with the following objectives: i) To determine the effect of herbicide on weed population in green gram field; ii) To determine the effect of herbicide application on growth, yield and benefit cost ratio of green gram crop.

Material and Methods

The field experiment, carried out at University farm during 2012 and 2013 in the New alluvial soil (*Inseptisol*) of Nadia (22° 93′ N, 88° 53′ E, 9.75 m above mean sea level), West Bengal, to study the effect of herbicide application on weed management in green gram [*Vigna radiata* (L.) Wilczek] was consisting of 14 treatments with three replications each; conducted in RBD (each plot size was 5 m × 2 m). The data obtained were analyzed statistically by the analysis of variance method [1]. The experimental soil were sandy loam under upland situation with good drainage facility, having soil pH 7.10, organic carbon 0.71 %, total nitrogen 0.08 %, available phosphorus 27.34 kg ha^{-1}, available potassium 132.15 kg ha^{-1} and were estimated by combined glass electrode pH meter method, Walkey and Black's rapid titration method, Modified macro Kjeldahl method, Olsen's method and Flame photometer method respectively [2]. The green gram variety IPM-2-3 was used for the experiment with recommended dose of fertilizer 20-40 kg^{-1} NPK, the entire dose of fertilizer was applied as basal, and then they were thoroughly mixed with the soil). The source of NPK was in the form of urea, single super phosphate and muriate of potash respectively. Population of different categories of weeds at 30 and 40 DAS was recorded by placing the quadrate of 50 cm × 50 cm at pre-determined locations in the sampling area. The values were converted to number/m^2. Grasses, broadleaved and sedges were counted separately and their sum was used to obtain total weed population. The weed samples for dry weight were collected from the area used for weed count on the same dates (30 and 40 DAS). The different weed management treatments being T_1: No weeding (weedy check), T_2: Hand weeding at 20 and 40 DAS, T_3: Total Weed free (Regular weeding as and when required), T_4: Quizalofop-p-ethyl@37.50 g *a.i.* ha^{-1}, T_5: Quizalofop-p-ethyl@75.00 g *a.i.* ha^{-1}, T_6: Pendamethalin@1 kg

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a.i. ha^{-1}, T_7: sPendamethalin @2 kg *a.i.* ha^{-1}, T_8: Imazethapyr@25 g *a.i.* ha^{-1}, T_9: Imazethapyr@40 g *a.i.* ha^{-1}, T_{10}: Imazethapyr @55 g *a.i.* ha^{-1},T_{11}: Fenoxaprop-p-ethyl@50 g *a.i.* ha^{-1}, T_{12}: Fenoxaprop-p-ethyl@100 g *a.i.* ha^{-1}, T_{13}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@0.75 kg *a.i.* ha^{-},T_{14}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@1.00 kg *a.i.* ha^{-1}. Generally, the time of application of herbicides were Quizalofop-p-ethyl at 16 DAS, Pendamethalin at 2 DAS, Imazethapyr at 16 DAS, Fenoxaprop-p-ethyl at 16 DAS and Vellore 32 at 2 DAS.

Results and Discussion

Weed flora

Eleven weed species were observed in experimental field; among them grasses were four, sedges one and remaining weed flora were from broad leaf category. The predominant weed species were *Digitaria sanguinalis*, *Cynodon dactylon*, *Eleusine indica*, *Echinochloa colona* amaong grasses; *Cyperus rotundus* among the sedges and the broad leaf weeds were *Cleome viscose*, *Chenopodium album*, *Euphorbia hirta*, *Digeria arvensis*, *Physalis minima* and *Amaranthus viridis*. Similar observation was also reported by Das et al. and Kundu et al. [3,4].

Number of broad leaf weeds/m^2

At 30 DAS, broad leaf weed population was highest in weedy check treatment (T_1). The lowest value of broad leaf weed population was recorded in T_3 (total weed free plot). All weed management treatments were significantly better than T_1. At 40 DAS also similar trend was observed (Table 1). All weed management treatments were superior to T_1. The highest suppression of broad leaf weed population was recorded in T_8 (Imazethapyr@ 25 g a.i. ha^{-1}), however it was statistically at par with most of the herbicide application treatments [except T_{12} (Fenoxaprop-p-ethyl@ 100 g a.i. ha^{-1})]. Most of the herbicides were found effective in controlling broad leaf weed population.

Number of grassy weeds/m^2

At 30 DAS, grassy weed population was highest in weedy check treatment (T_1). The lowest number of grassy weed population was recorded in T_3 (total weed free plot). All weed management treatments were significantly better than T_1. Most of the herbicides were better than the hand weeding treatment (T_2) in managing grassy weeds (Table 1). Similar observation was noticed at 40 DAS. The highest suppression of grassy weed population was recorded in T_3 which was statistically superior to all other treatments. The population of grassy weeds was quite high in weedy check treatment (T_1).The herbicides like Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC), Pendimethalin, Imazethapyr, and Fenoxaprop-p-ethyl were found effective in controlling grassy weed population.

Number of sedge weeds/m^2

Sedge weed population was slightly lower than grassy and broad leaf weeds on both the date of observations. At 30 DAS, sedge weed population was maximum in weedy check treatment (T_1). The minimum number of sedge weed population was recorded in T_3 (total weed free plot). All weed management treatments were significantly better than T_1. Most of the herbicides were ineffective than the hand weeding treatment (T_2) in managing sedge weeds (Table 1). More or less similar type of data was recorded at 40 DAS. The highest suppression of sedge weed population was recorded in T_3 which was statistically superior to all other treatments. The population of sedge weeds was quite high in weedy check treatment (T_1). The herbicides like Imazethapyr, Pendimethalin, and Quizalofop-p-ethyl were found effective in controlling sedge weed population. The treatment T_2 (hand weeding at 20 and 40 DAS) was also effective in controlling sedge weed population.

Leaf area index (LAI)

Leaf area index is an important growth factor of a crop. LAI of the crop was determined at 30, 45 and 60 DAS and are presented in Table 2. Among three occasions the more values of LAI were recorded in 45 DAS in comparison with 30 and 60 DAS.

It is evident that the leaf area index at 30 DAS was highest in T_3 (total weed free plot) which was closely followed by the treatments like T_2 (hand weeding at 20 and 40 DAS), T_{14} [Vellore 32 (Pendimethalin

Treatment	No. of broad leaf weeds/m^2		No. of grassy weeds/m^2		No. of sedge weeds/m^2	
	30 DAS	40 DAS	30 DAS	40 DAS	30 DAS	40 DAS
T_1	30.94	40.29	65.40	67.27	22.43	27.93
T_2	15.98	20.89	16.27	17.29	6.44	7.44
T_3	1.48	1.50	1.22	1.50	1.75	2.50
T_4	20.33	21.11	11.88	20.78	12.50	14.49
T_5	16.73	19.49	13.23	17.60	14.00	17.51
T_6	20.94	22.45	14.48	21.44	10.00	15.48
T_7	15.99	20.20	12.61	16.5	10.00	15.32
T_8	13.40	16.93	14.01	18.48	11.50	15.88
T_9	15.45	17.90	12.22	23.32	11.50	12.95
T_{10}	15.88	19.96	13.11	21.01	11.00	15.51
T_{11}	13.04	21.88	15.22	16.04	16.00	16.72
T_{12}	19.34	22.23	13.66	19.51	13.50	16.73
T_{13}	14.85	17.22	13.55	17.44	12.50	19.61
T_{14}	14.44	21.88	13.22	18.44	12.00	17.99
SE m (±)	1.26	1.61	0.72	0.80	1.42	1.55
CD at 5%	3.80	4.85	2.22	2.46	4.29	4.69

Note T_1: No weeding (weedy check); T_2: Hand weeding at 20 & 40 DAS; T_3: Total Weed free (Regular weeding as and when required); T_4:Quizalofop-p-ethyl@37.50 g *a.i.* ha^{-1}; T_5:Quizalofop-p-ethyl@75.00 g *a.i.* ha^{-1}; T_6: Pendamethalin@1 kg *a.i.* ha^{-1}; T_7: Pendamethalin@2 kg *a.i.* ha^{-1}; T_8: Imazethapyr @ 25 g *a.i.* ha^{-1}; T_9: Imazethapyr@40 g *a.i.* ha^{-1}; T_{10}: Imazethapyr@55 g *a.i.* ha^{-1}; T_{11}: Fenoxaprop-p-ethyl@50 g *a.i.* ha^{-1}; T_{12}: Fenoxaprop-p-ethyl@100 g *a.i.* ha^{-1}; T_{13}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@0.75 kg *a.i.* ha^{-}; T_{14}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@1.00 kg *a.i.* ha^{-1}.
*DAS: Days after sowing.

Table 1: Effect of herbicides on weed population of green gram crop. (Pooled data of two years).

Treatment	Leaf area index			Dry mass of aerial plant parts (g/m²)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1	2.19	2.67	1.56	19.88	73.49	145.40
T_2	3.23	4.15	4.02	26.83	128.51	333.56
T_3	3.32	4.38	4.14	27.95	130.25	360.83
T_4	2.75	3.51	3.28	24.02	105.82	232.50
T_5	2.86	3.54	3.36	24.67	109.84	264.13
T_6	3.02	4.00	3.91	26.45	126.85	306.53
T_7	3.06	4.06	4.03	27.00	127.36	312.25
T_8	2.72	3.49	3.44	24.33	115.66	256.00
T_9	2.97	3.66	3.60	25.21	119.05	300.30
T_{10}	2.91	3.57	3.43	25.09	121.00	285.62
T_{11}	2.65	3.38	3.21	21.86	110.63	216.97
T_{12}	2.70	3.45	3.16	22.04	108.76	225.36
T_{13}	3.08	3.79	3.71	26.05	120.37	300.94
T_{14}	3.14	4.22	4.06	26.13	126.42	316.22
SE m (±)	0.10	0.24	0.16	0.72	3.42	7.16
CD at 5%	0.31	0.74	0.50	2.18	10.27	21.50

Note T_1: No weeding (weedy check); T_2: Hand weeding at 20&40 DAS; T_3: Total Weed free (Regular weeding as and when required); T_4: Quizalofop-p-ethyl@37.50 g *a.i.* ha^{-1}; T_5: Quizalofop-p-ethyl@75.0 g *a.i.*ha^{-1}; T_6: Pendamethalin@1 kg *a.i.* ha^{-1}; T_7: Pendamethalin@2 kg *a.i.* ha^{-1}; T_8: Imazethapyr@25 g *a.i.* ha^{-1}; T_9: Imazethapyr@40 g *a.i.* ha^{-1}; T_{10}: Imazethapyr@55 g *a.i.* ha^{-1}; T_{11}: Fenoxaprop-p-ethyl@50 g *a.i.* ha^{-1}; T_{12}: Fenoxaprop-p-ethyl@100 g *a.i.* ha^{-1}; T_{13}:Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@0.75 kg *a.i.* ha^{-}; T_{14}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC) @1.00 kg *a.i.* ha^{-1}.

Table 2: Effect of herbicides on Leaf area index and Dry mass of aerial plant parts (g/m²) of green gram crop. (Pooled data of two years).

30 EC+Imazethapyr 2 EC)]@1.00 kg a.i. ha^{-1}), T_{13} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)]@0.75 kg a.i. ha^{-1})), T_7 (Pendimethalin@2 kg a.i. ha^{-1}) and T_6 (Pendimethalin@1 kg a.i. ha^{-1}), there was no significant difference and they were statistically at par . The lowest value of leaf area index was obtained in weedy check (T_1) which was significantly lower than all other treatments. At 45 DAS also, the highest LAI was recorded in T3 (total weed free treatment), it was, however, at par with T_2 (hand weeding at 20 and 40 DAS),T_{14} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)]@1.00 kg a.i. ha^{-1}) T_{13} [Vellore 32 (Pendimethalin 30 EC + Imazethapyr 2 EC)@0.75 kg a.i. ha^{-1}], T_7 (Pendimethalin@2 kg a.i. ha^{-1}), T_6 (Pendimethalin@ 1 kg a.i. ha^{-1}) and T_9 (Imazethapyr@40 g a.i. ha^{-1}). The leaf area index was observed lowest in weedy check which was significantly lower than all other treatments except T_{11} (Fenoxaprop-p-ethyl@50 g a.i. ha^{-1}).

On an average the LAI value was decreased slightly at 60 DAS as the crop reached its maturity stage. At this stage also highest leaf area index was found in T_3 (total weed free treatment), it was, however, at par with T_2 (hand weeding at 20 and 40 DAS), T_{14} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@1.00 kg a.i. ha^{-1}], T_{13} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@0.75 kg a.i. ha^{-1}], T7 (Pendimethalin@ 2 kg a.i. ha^{-1}) and T_6 (Pendimethalin@1 kg a.i. ha^{-1}). The lowest value of LAI was recorded in weedy check (T_1) which was significantly lower than all other treatments. The better treatments in this field of discussion were T_3, T_2 and T_{14}. The observations were well consistent with that of Singh et al. Srivastava et al [6,7].

Dry matter accumulation

The real picture of crop growth can be obtained from the data of dry matter accumulation. Dry mass of aerial parts of plants/m² was determined in this experiment determined at 30, 45 and 60 DAS and presented here (Table 2) as dry matter accumulation of green gram crop. Dry biomass of the crop increased gradually with the age of the crop. At 30 DAS, the highest dry matter accumulation was recorded in T_3 (total weed free treatment), however, it was statistically at par with T_2 (hand weeding at 20 and 40 DAS), T_7 (Pendimethalin@ 2 kg a.i. ha^{-1}), T_6 (Pendimethalin@ 1 kg a.i. ha^{-1}), T_{14} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@ 1.00 kg a.i. ha^{-1})] and T_{13} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@0.75 kg a.i. ha^{-1}]. The lowest value (19.88 g/m²) was observed in weedy check (T_1).

Yield components and seed yield

Yield of green gram crop is influenced by a number of yield attributing characters, like number of pods/m², number of seeds/pod and test weight of seeds. Observation on yield attributes or components like numbers of pods/square meter, numbers of seeds/pod, test weight of seed (1000 seed weight) and seed yield were recorded at the time of harvest and have been presented in the Table 3.

Number of pod/m²

In pulse crops number of pods/m² is the most important determinant of grain or seed yield. The number of pods/m2, which normally gives a more reliable or accurate picture and contributing most in determining the yield, is presented here as main yield component (Table 3). The number of pods/m² ranged from 208.0 in T_1 (control treatment) to 443.2 in T_3 (total weed free treatment). In T_3 maximum number of pods/m² was obtained and it was followed by T_2 and T_{14}; treatments T_3 and T_2 were, however, statistically at par with each other. All weed management treatments were significantly better than T_1 (control treatment). Treatments T_{11}, T_{12} and T_4 were statistically at par, but these three treatments produced significantly lower number of pods than other weed management treatments. Among the herbicides Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC) and Pendimethalin produced more number of pods/unit area. The results confirm the findings of Kumar et al. Veeraputhiran and Singh et al [5,7,8].

Number of seeds/pod

Number of seeds/pod is another important yield component of green gram crop. The weed management treatments had no significant effect on number of seeds/pod. The number of seeds/pod varied from 9.60 in T_1 (control treatment) to 10.15 in T_3 treatment (total weed free), however, there was no significant difference and all the treatments were statistically at par (Table 3).

Treatment	No. of pods/m^2	No. of seeds /pod	Test weight (g)	Seed yield (Kg ha^{-1})	B : C ratio
T_1	208.0	9.60	39.89	460	1.24
T_2	409.7	10.10	41.20	970	2.08
T_3	443.2	10.15	39.39	1005	1.83
T_4	281.3	9.80	41.05	758	2.16
T_5	331.6	9.70	40.12	827	2.15
T_6	381.0	9.65	38.95	912	2.53
T_7	377.6	10.00	40.70	910	2.26
T_8	317.4	10.05	39.80	803	2.45
T_9	361.9	9.90	40.02	900	2.69
T_{10}	339.5	9.95	39.40	864	2.55
T_{11}	256.8	9.80	38.16	680	1.99
T_{12}	263.3	9.85	39.60	706	1.93
T_{13}	370.3	10.00	40.80	905	2.75
T_{14}	402.1	10.10	40.45	925	2.75
SE m (±)	12.1	0.19	1.14	30.4	-
CD at 5%	36.4	NS	NS	91.4	-

Note T_1: No weeding (weedy check); T_2: Hand weeding at 20 and 40 DAS; T_3: Total Weed free (Regular weeding as and when required); T_4: Quizalofop-p-ethyl@37.50 g *a.i.* ha^{-1}; T_5: Quizalofop-p-ethyl@75.00 g *a.i.* ha^{-1}; T_6: Pendamethalin@1 kg *a.i.* ha^{-1}; T_7: Pendamethalin@2 kg *a.i.* ha^{-1}; T_8: Imazethapyr@25 g *a.i.* ha^{-1}; T_9: Imazethapyr @40 g *a.i.* ha^{-1}; T_{10}: Imazethapyr @55 g *a.i.* ha^{-1}; T_{11}: Fenoxaprop-p-ethyl@50 g *a.i.* ha^{-1}; T_{12}: Fenoxaprop-p-ethyl @100 g *a.i.* ha^{-1}; T_{13}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@0.75 kg *a.i.* ha^{-}; T_{14}: Vellore 32 (Pendamethalin 30 EC+Imazethapyr 2 EC)@1.00 kg *a.i.* ha^{-1}.

Table 3: Effect of herbicides on Yield components, Seed yield and Benefit - cost ratio (B: C ratio) of green gram crop.

Test weight of seeds

The test weight of seeds (refers to 1000 seed weight) generally does not vary so much. In this experiment also the differences in test weight (Table 3) were at par (statistically non-significant). The test weight of seed was highest in T_2 and it was lowest in T_{11}, however, there was no significant difference.

Seed yield

Seed yield of the crop was distinctly influenced by the weed management treatments. The maximum seed yield was obtained in T_3 (total weed free treatment) followed by T_2 (hand weeding at 20 and 40 DAS) and T_{14} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@1.00 kg a.i. ha^{-1})]. The minimum seed yield was obtained in T_1 (control-weedy check). The reduction in yield under the control treatment (i.e. in T_1) may be attributed to reduced growth and number of plants and number of pods per unit area. The average seed yield obtained was significantly more with weed management. Crop performance was not good in the control treatment, thus, the yield per hectare was significantly lower than that obtained in other treatments (Table 3). The reduction in seed yield in weedy treatment as compared to hand weeded and total weed free were 160% and 169%, respectively. Seed yield was reduced by Fenoxaprop-p-ethyl treatments (T_{11} and T_{12}) in comparison with other herbicidal treatments. The results are in conformity with the findings reported by Yadav and Singh, Singh et al, Singh et al, Srivastava, Malik et al, and Veeraputhiran [5,6,8-11].

Benefit-cost ratio

From the data it was clear that the benefit : cost ratio was highest in T_{14} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@1.00 kg a.i. ha^{-1})] and that was closely followed by T_{13} [Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@0.75 kg a.i. ha^{-1})], T_9 (Imazethapyr@40 g a.i. ha^{-1}), T_{10} (Imazethapyr@55 g a.i. ha^{-1}), T_6 (Pendimethalin@1 kg a.i. ha^{-1}) and T_8 (Imazethapyr@25 g a.i. ha^{-1}). The treatments like T_3 (total weed free treatment) and T_2 (hand weeding at 20 and 40 DAS) although produced higher seed yield but the B: C ratios were low due to high cost of cultivation. The weedy check treatment (T_1) had the lowest B: C ratio due to poor yield in this treatment. The tremendous weed infestation in weedy check treatment drastically reduced the yield of the crop. Similar findings were also reported by Kundu et al. and Randhwa et al. [12,13]. The treatments like T_{14}, T_{13}, T_9, T_{10}, T_6 and T_8 are economically viable and the concerned herbicides are effective for weed management of green gram crop.

Conclusion

From the result it can be concluded that all the weed control treatments effectively controlled weeds and significantly reduced their population and dry weight. However, application of Vellore 32 (Pendimethalin 30 EC+Imazethapyr 2 EC)@1.00 kg a.i. ha^{-1} was found most effective in reducing population and dry mass of weeds and producing maximum yield of green gram.

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